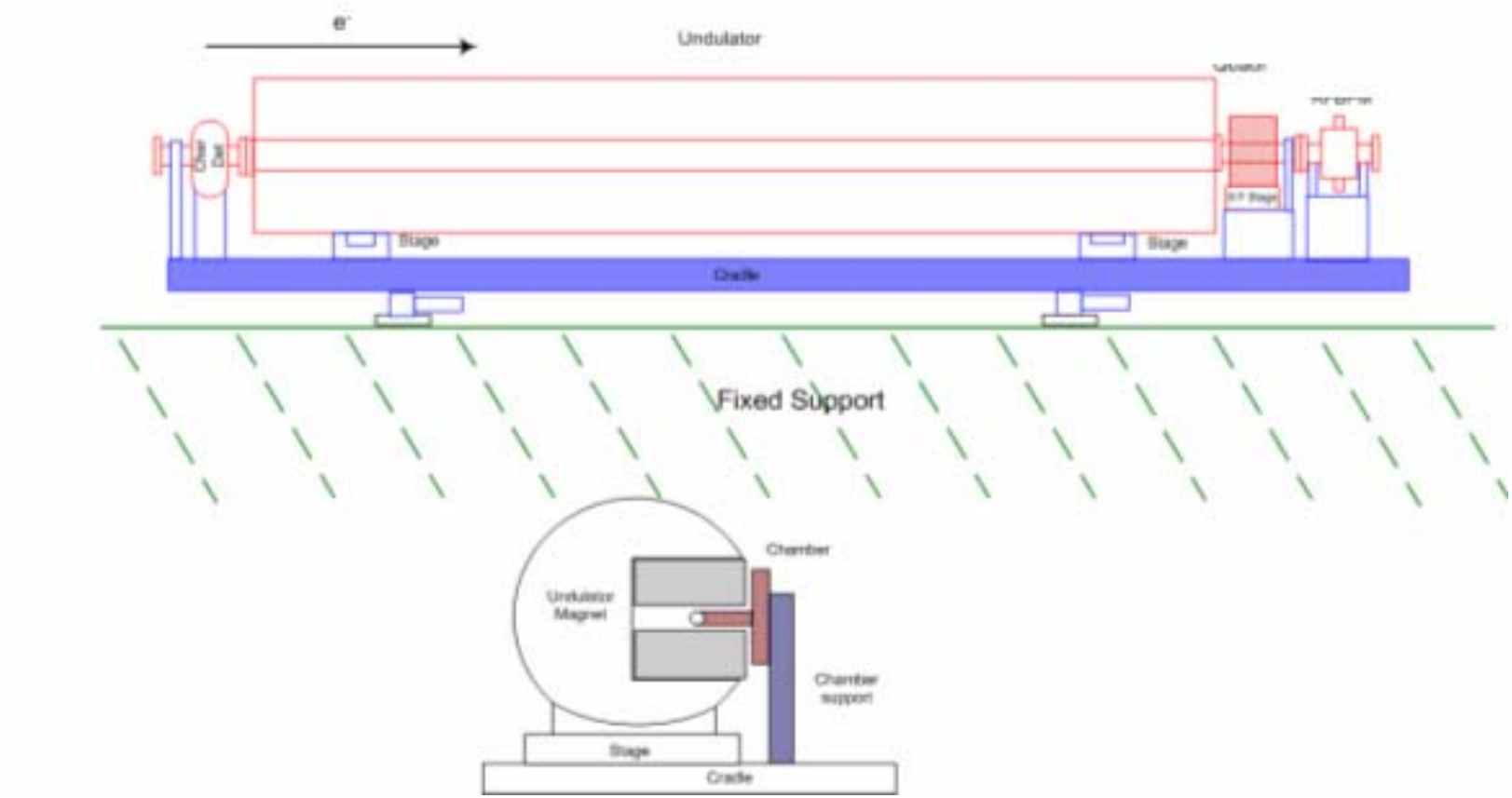
LCLS Undulator Support System



LCLS Fixed Support Girder

LCLS Fixed Support Girder

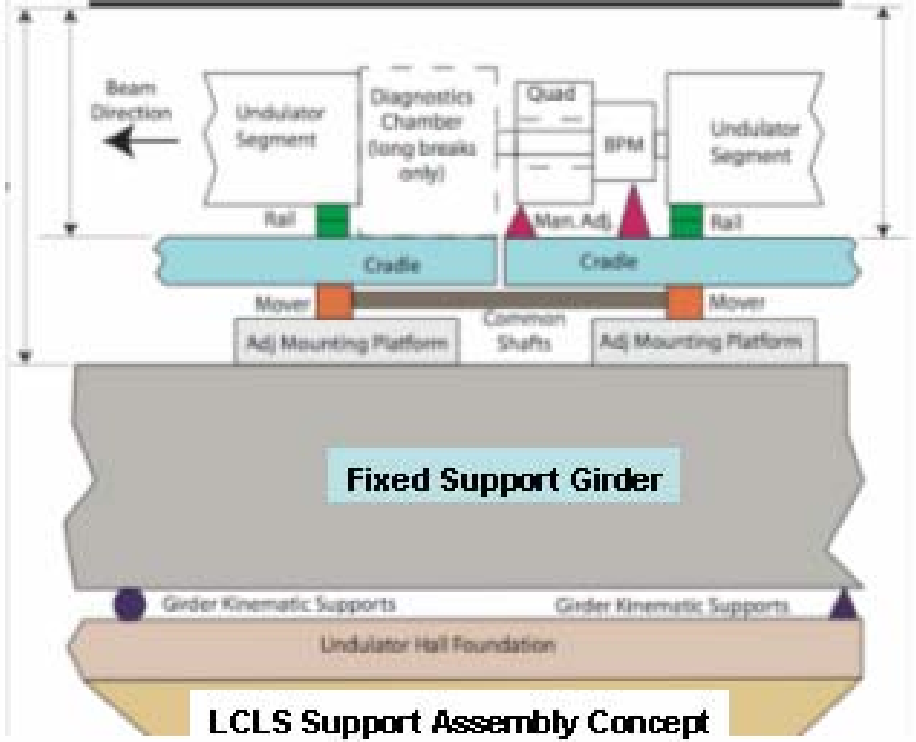
→ APS Pedestals

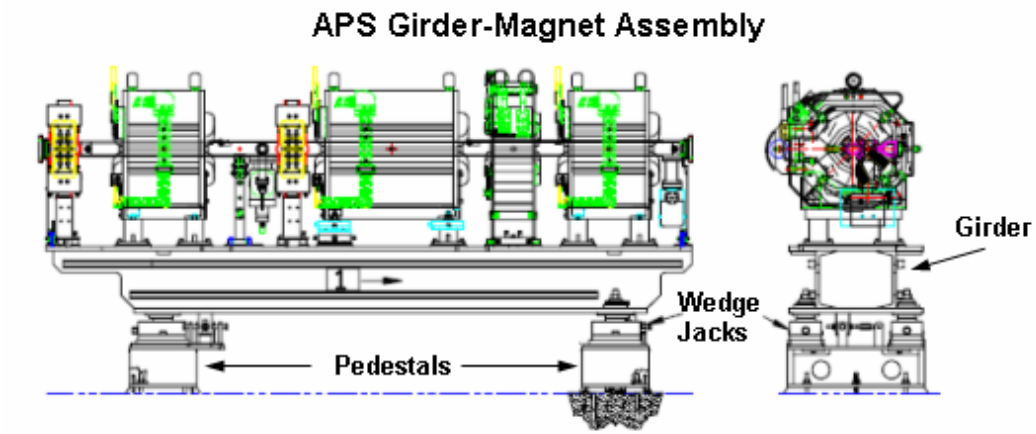
LCLS Mounting Platform + Mover

→ APS Wedge Jacks

LCLS Cradle

→ APS Girder





April 19, 2005

S. Sharma (APS)

Fixed Support Design Criteria

LCLS Specification #1.4 -001

- Short term (10 h) BPM and Quad stability: ± 1 μm
- BPM and quad stability to position sensors : 1 μm
- Quad center long term (2 months) stability wrt CA: 4 μm
- BPM center long term (2 month) stability wrt CA: 1 μm

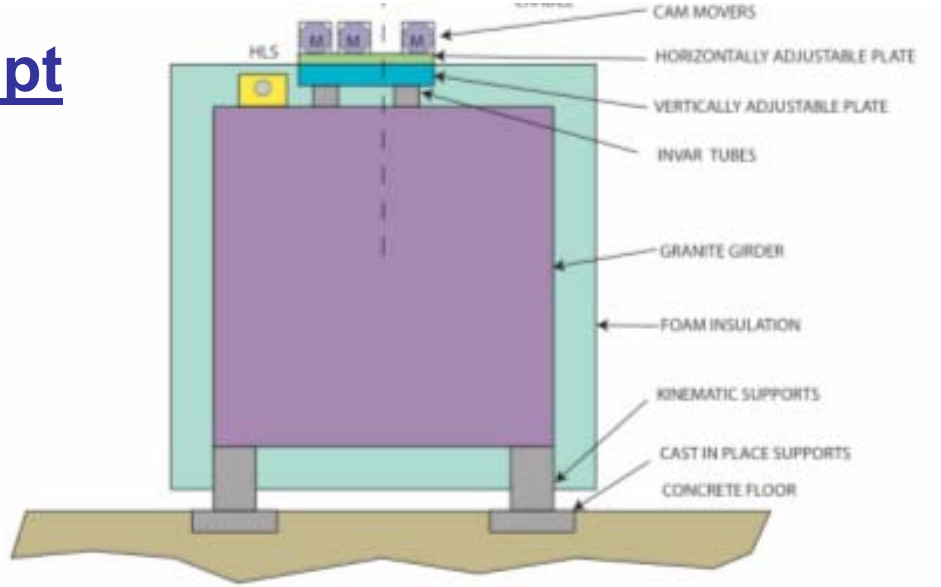
- Max. horizontal earthquake acceleration: 2 g
- Max. vertical earthquake acceleration: 1g

- Relative floor settlement at 10 m (LCLS-TN-04-14): ~ ± 1 μm / day
- Undulator tunnel temperature stability: ± 0.2° C
- Max. floor settlement (LCLS-TN-04-14): ± 25 mm
- Changes in heat flux: 3 W/m^2

Present Fixed Support Concept

A granite girder is proposed instead of pedestals.

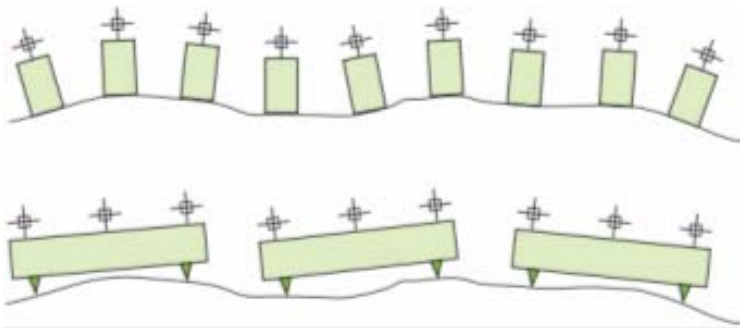
This is supposed to reduce phase error (by a factor of 5) caused by ground settlement between scheduled beam-based alignment (BBA) sessions.

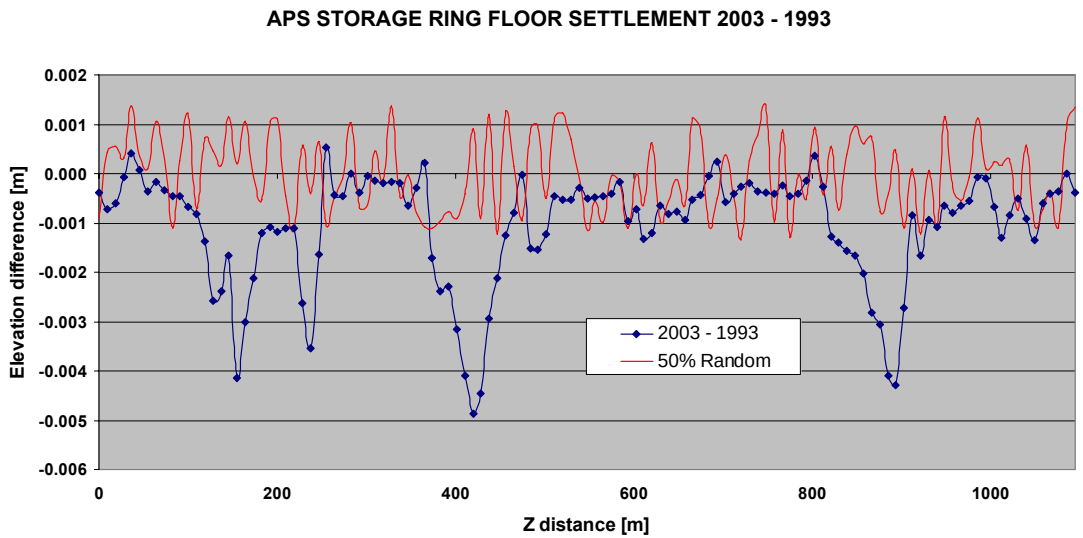


- **12 meter long granite girder each supporting 3 undulators and 3 quads.**
- **Approximate cost of 0.8mx0.8mx12m granite block is $40,000.**
- **Granite girder is to be enclosed in water-cooled thermal insulation.**
- **The girder is mounted on kinematic supports (not yet designed).**

Phase Error Calculations

- Calculations are based on 20 μm uncorrelated (random) floor settlement between BBA sessions.
- Average APS floor settlement is ~ 1.5 μm/day (correlated +uncorrelated).
- Long girders provide no advantage when APS settlement (normalized to 20 μm) is used in the calculations.
- Comparisons between short and long girders is to exclude correlated part of the settlement. Why ?





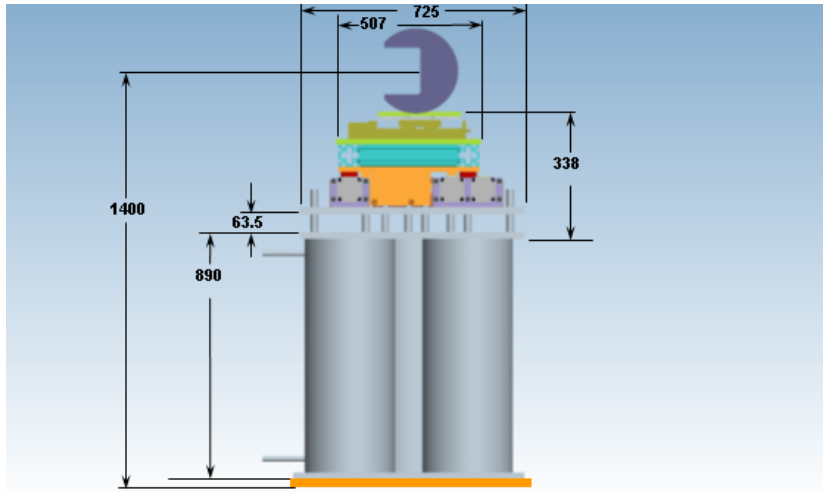
Correlated vs Uncorrelated Ground Settlement

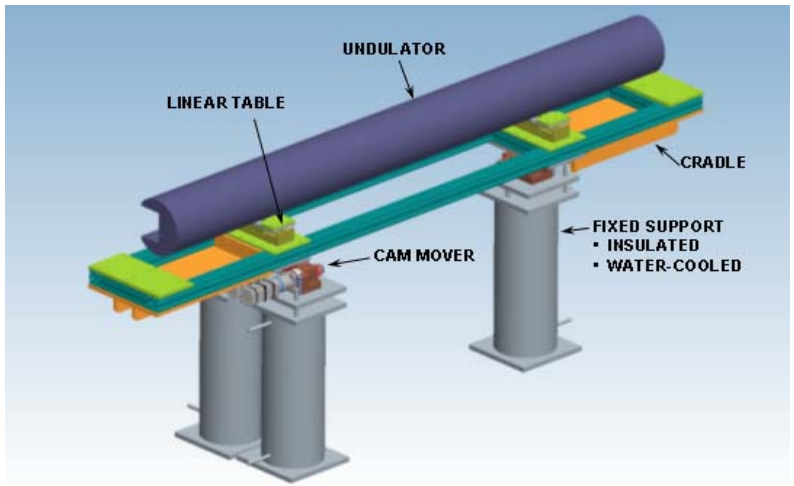
…..Paul (Emma) has developed a fine tuning scheme that is ancillary to BBA which would largely take out this kind of error. He does this by *selecting and moving only a few of the most important quadrupoles* (equivalent to using the new EM correctors) to minimize the BPM readings. *This kind of correction can be done much more quickly than full scale BBA, perhaps on a daily basis without significant disruption to the experimental program. As a result of your probing and discussions with Paul I am going to incorporate Paul's fine tuning scheme into my tolerance analysis and see what happens……*
(Jim Welch's email of April 11, 2005)

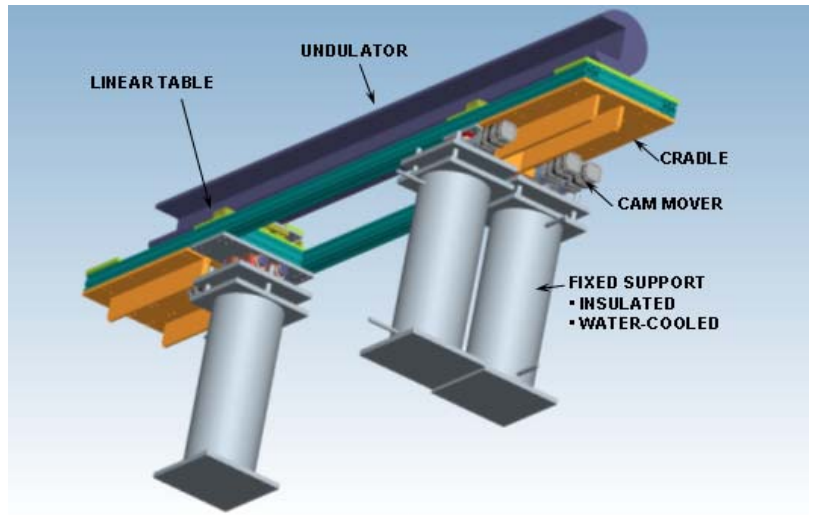
- **Phase error for APS-type settlement is ~ 55° as compared to ~ 360° from the uncorrelated model.**
- **Can the effect of correlated ground settlement be tuned out ?**
- **How large is uncorrelated settlement as a fraction of total settlement ?**
  (uncorrelated settlement of ~ 10 μm → phase error ~ 85°)
- **Can we assume long granite girders and their kinematic supports to be perfectly rigid and thermally stable ?**

Fixed Supports - Option 1:

- **Maintain 1.4m beam height.**
- **Water-cooled cylindrical steel supports.**
- **Thermally insulated.**
- **Viscoelastic damping is used to reduce cradle vibrations.**





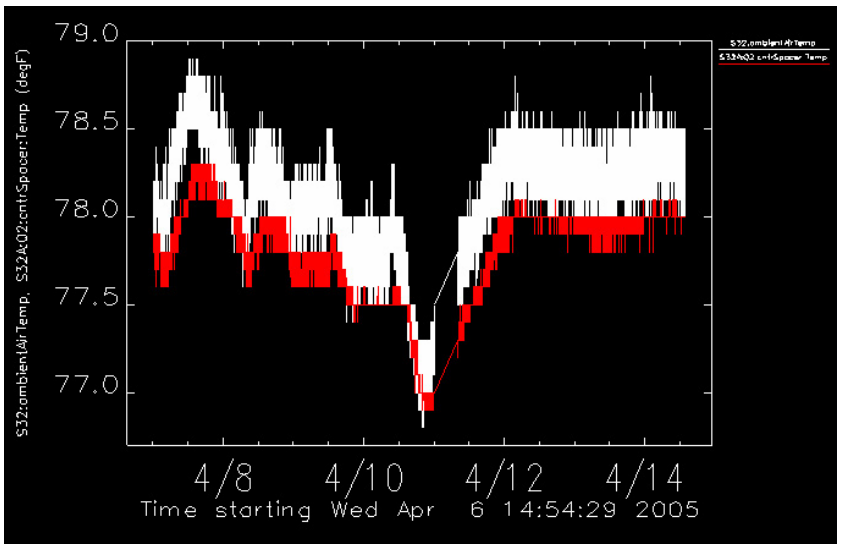


Fixed Support Thermal Stabilization

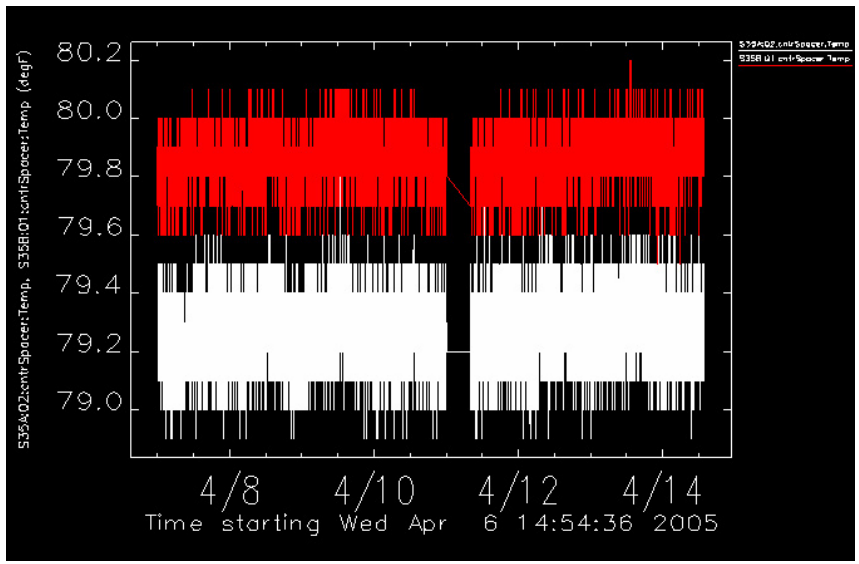
Case 1: APS sand-filled, insulated XBPM stand

Case 2: APS water-cooled, insulated 4-jaw pinhole stand

- Better performance by a factor of ~4.
- For further improvement:
  - Reduce water temperature fluctuations.
  - Reduce water flow



Sand-Filled, Insulated XBPM Stand

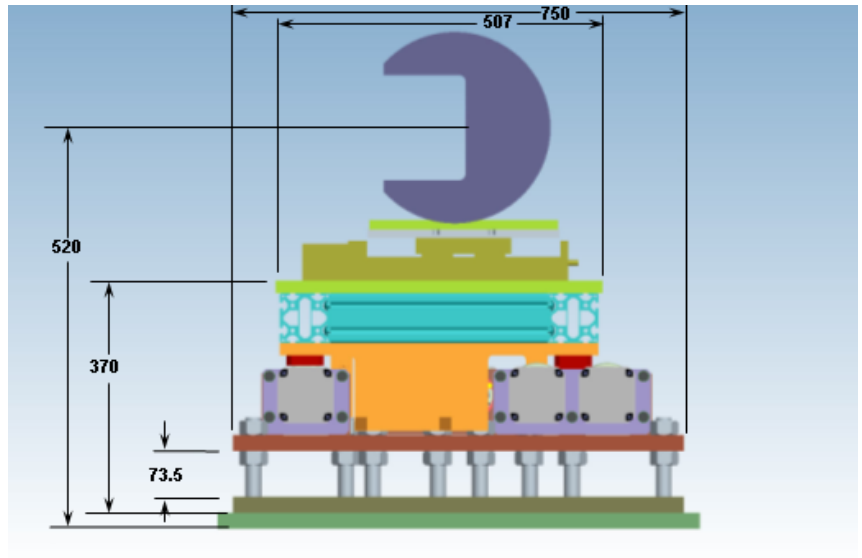


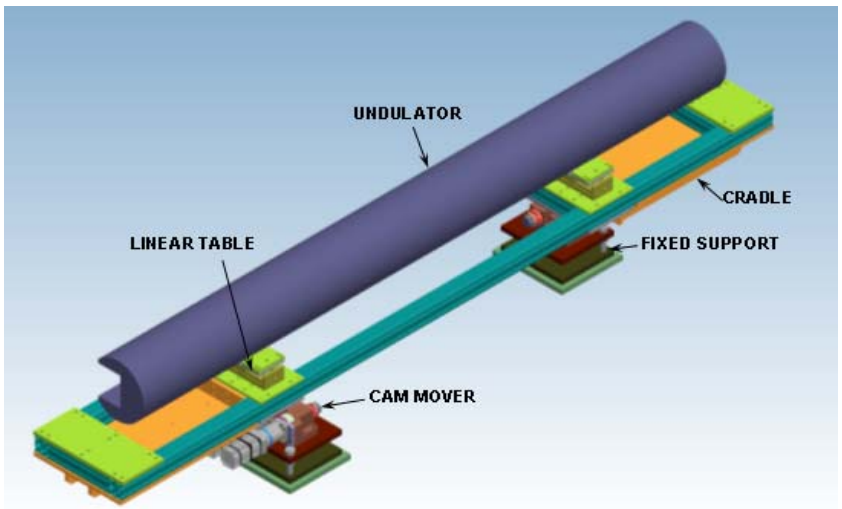
Water-Cooled, Insulated Pinhole Stand

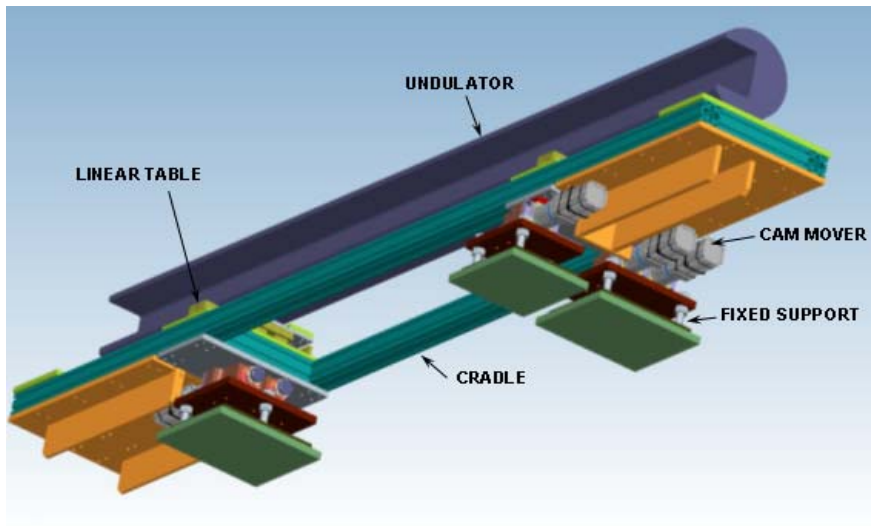
Fixed Supports – Option 2 (Pedestals):

Same as Option 1 without the SS columns.

Pedestals may be thermally insulated if necessary.

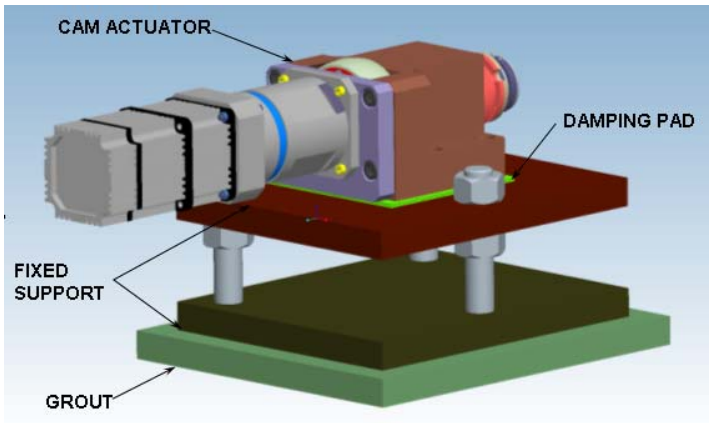


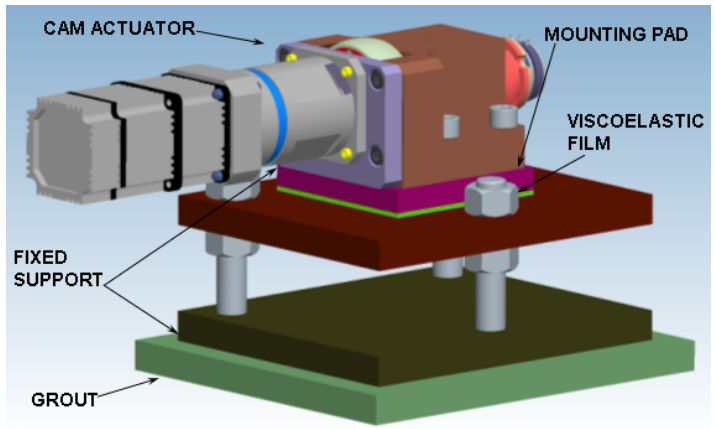




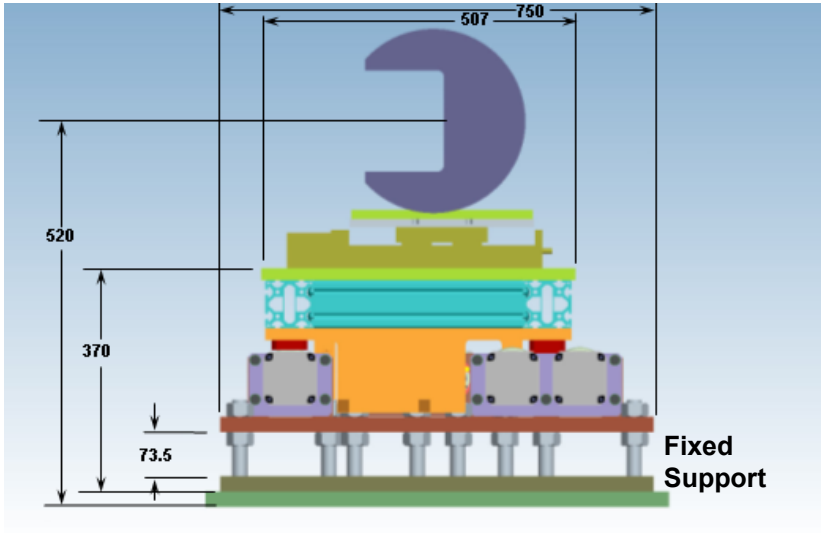
Fixed Support with Vibration Damping

- **Concept 1: Cam movers sit freely on viscoelastic damping pads. Must prevent tipping over under 2g horizontal acceleration.**
- **Concept 2: Cam mover is bolted to a mounting pad.**





Summary



- **Short pedestals provide a cost-effective solution for the "Fixed Support."**
- ***It is not obvious that the overall support system (fixed support + cam movers + cradle + linear tables) will meet the design specification of ± 1 µm transverse stability.***